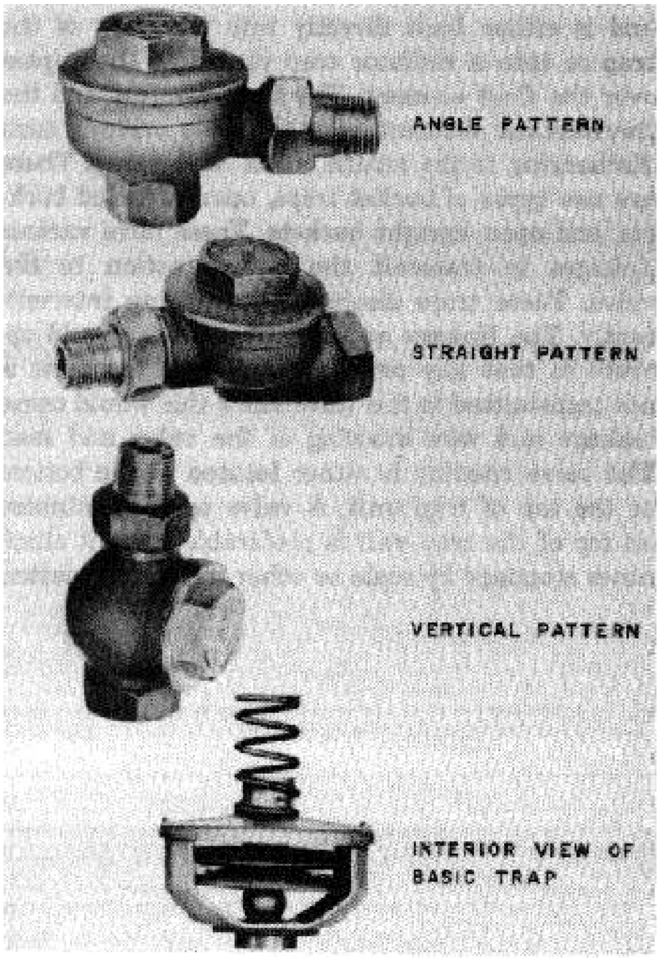


Figure 4-25. Thermostatic traps (diaphragm type).

a. Installation.

(1) It is important to install traps so that the trap inlet is at or below the steam chamber and to connect the discharge opening to the return piping so that condensate will return by gravity to the steam main. Thermostatic traps do not lift or siphon condensate from a steam radiator. The top water line of a trap should be the top water line in the steam space served by the trap to ensure proper condensate drainage. Lower heat emission and efficiency of a heating unit may result due to partial filling of the steam space by water which is backed or held in the heating unit by a clogged or defective trap or a trap set too high.

(2) The thermostatic trap is set so that the axis of the bellows or diaphragm is vertical to assure that the thermostatic element is not partly immersed in condensate.

(3) The return pipe connections should be arranged so that expansion and contraction of the mains does not place strains on the trap.

(4) After the heating system piping, boilers and other equipment are cleaned and in operation, shut each radiator valve and remove the cap of each thermostatic trap after the thermostatic unit has cooled. Do not open thermostatic traps when they are hot or when high vacuum is present in the returns, since permanent distortion may occur to the diaphragm or bellows. After the cap is removed clean the trap interior, valve, and seat carefully with a clean cloth. Do not clean seats, valve discs or heads with abrasives, emery cloth, or files as permanent scoring may result. It is important to clean the trap during initial periods of new plant operation as often as necessary and also immediately following the shut-down of the heating system for summer lay-up.

(5) When removing caps, use wrenches furnished by the trap manufacturer to avoid damage to heads and caps. Before replacing caps, carefully wipe the threads clean and coat lightly with oil.

b. Maintenance.

(1) Clean the interior of thermostatic traps, including diaphragm, valve seat and heads as required by manufacturer's instructions or as often as required if water conditions cause excessive deposit of solids, greases, or scale.

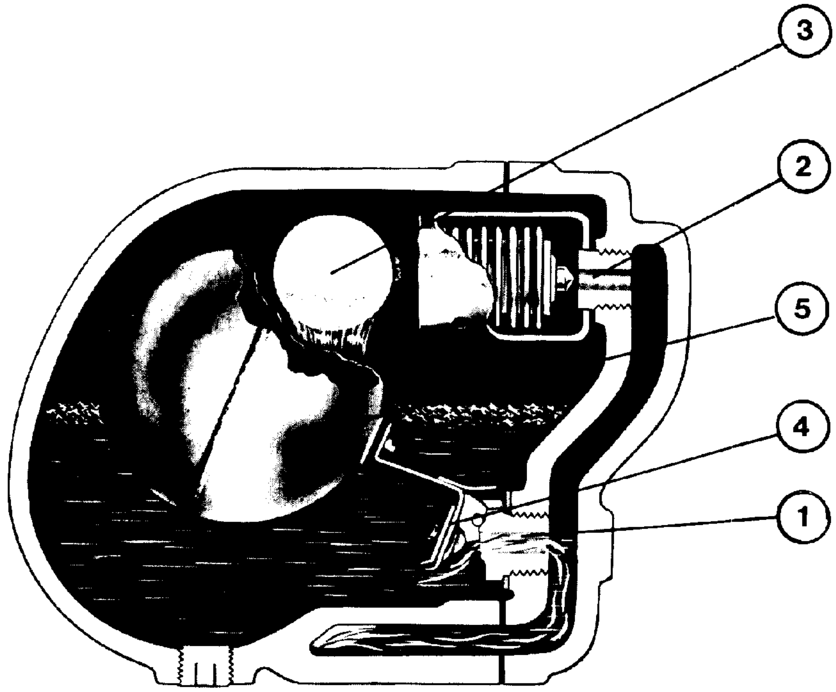
(2) A simple inspection check of the diaphragm or bellows is accomplished by shaking the diaphragm near the ear. Note by sound whether or not the diaphragm contains liquid. Pull the valve head to expand the thermostatic element slightly and then compress to detect the sound of air or liquid leaks. If the diaphragm or bellows leaks, it must be replaced with a new element. Do not refill diaphragms, or patch and solder leaks, since charging and closing thermal elements requires a factory process with exact procedures and exceedingly close tolerances.

(3) If the valve head is damaged or scored, remove it from the thermal element and replace it if possible; otherwise, install a new diaphragm or redress with special tools which are available from the trap manufacturer. To regrind trap seats or discs, it is necessary to shim the diaphragm in resetting, with shims available from the manufacturer to compensate for metal removed from the valve head or seat. Do not regrind or cut valve seats of the replaceable type, since the trap setting is disturbed by excessive removal of metal.

c. Typical operating difficulties. Faulty traps will cause readily discernible operating difficulties. Radiators will fail to heat due to air binding. This may be caused by clogged traps or burst diaphragms. Bellows expand on release of their internal vacuum and close the valve. Return lines become excessively hot due to cut valves and seats which allow excessive steam leakage into return mains. Radiators will pound or have considerable water surging sounds when the trap lacks capacity, when trap is not properly set at the bottom of eccentric radiator outlet bushings, or when the trap is clogged. Defective traps should be returned to manufacturers for repair or replacement.

4-46. Float and thermostatic traps and bucket traps.

These traps are installed on high capacity heating units such as unit heaters, blast coils, and hot water supply heaters. F&T traps are also used to drip ends of steam mains of closed vapor and vacuum heating systems. F&T traps consist primarily of two elements: the float section which is intended to handle the condensate, and the thermostatic element which consists of a diaphragm or bellows unit to pass air and gases. (See figure 426). The thermostatic element is an exact duplication of the thermostatic element of a radiator trap and is either built directly into the body of the trap or into a radiator trap placed in the bypass over the float element. The float element and the thermostatic element have separate orifices, each discharging to the return outlet of the trap. There are two types of bucket traps, open inverted buckets, and open upright buckets. These have various linkages to transmit the bucket action to the valve. These traps discharge condensate intermittently. The linkage or leverage system should operate so that any pulsating action of the float is not transmitted to the valve since this would cause leakage and wire drawing of the valve and seat. The valve opening is either located at the bottom or the top of trap unit. A valve opening situated on top of the trap unit is preferable since it eliminates stoppage by scale or other entrained matter.



1. CONDENSATE DISCHARGE PORT
2. THERMOSTATIC AIR VENT
3. CONDENSATE INLET
4. CONDENSATE DISCHARGE VALVE
5. FLOAT

Figure 4-26. Float and thermostatic (F&T) trap.

a. Installation. Float traps will not siphon or lift condensate. The float trap must be installed so that the top water line of the trap is below the bottom of the equipment to be drained. The float trap must be set level to eliminate binding of the leverage system. Trap connections at the end of mains should include a shut-off valve, vertical drop or dirt pocket, strainer, and finally a drop into the return main. The bottom of the dirt pocket should be fitted with an easily removable cap for blowdown and removal of dirt, scale, and grease. Float traps installed on unit heaters or other equipment which have readily accessible steam shutoff valves at the supply connection, need not be provided with shutoff valves.

b. Operation and cleaning. After completion of replacement, remove any temporary blocks or ties which are present to hold the float mechanism during shipping and installation. If the trap is equipped with a priming plug, open and fill the trap with water. If a priming plug is not provided, open the valve to the steam line or heating unit supply valve and allow the trap to prime as condensate accumulates in the body. This process may entail a short period of steam leakage. Open caps of strainers and dirt pockets preceding traps at frequent intervals, or as indicated necessary, to assure removal of any accumulation of grease and scale. After traps have been in service on new installations for a short period, remove covers, valve head and seat, and wipe the internal mechanism thoroughly with a clean cloth to remove initial grease, scale, and accumulations of core sand. Periodic opening of the trap drain plugs and blowdown is effective in maintaining good trap service.

c. Maintenance. Check traps frequently to be sure that they are operating properly. A correctly operating trap has a definite open and closed position, and the sound of condensate flow and shutoff can be detected easily by listening closely at the discharge piping of the trap. Use a stethoscope to check trap operation. Holding the stethoscope to the trap body in the area of discharge provides a satisfactory method for checking trap performance. Repair or replace a trap immediately upon detection of blowing steam. This condition disrupts functioning of the heating system and further damage to the trap will result because of the cutting action of wet steam and condensate flowing through a scored or restricted opening. Blowing or leaking traps will also cause excessively hot returns. Inspect operating elements periodically; float failures or leakage of the ball or other closed type floats closes the valve and causes backup of condensate. Failure of an upright open bucket trap element results in blowby but not in backup of condensate. This failure is safe since backup of condensate could result in freezeup of extended surface coils used in ventilating work and of other steam units exposed to ambient conditions. Keep a shop supply of serviced traps for quick replacement so that equipment need not be shut down during repair operations.

d. Typical operating difficulties.

(1) Steam leakage or blowby is the most common difficulty and is caused by float failures, a worn linkage or lever system, cut valves, or excessive accumulations of dirt, rust, scale, and grease.

(2) Pounding and noise (water-hammer) in a heating unit or steam main indicates backup of condensate due to inadequate trap capacity. Steam traps should be sized for 250 percent of the heating unit capacity to permit excess condensate removal during cold start-up. Noise is also caused by clogged traps or defective or jammed float mechanisms.

(3) Air binding due to failure of the thermostatic element causes heating equipment failure and is usually detected by a relatively cool area preceeding the trap. Air binding creates an air pocket which prevents steam from filling the steam space of the heating unit and the top of the trap. When this condition is present, backing off the thermostatic element cover or opening the cleanout plug will result in a rush of air followed by a rush of condensate and steam. To correct this condition, service the thermostat unit which may be either clogged or closed by a ruptured thermostatic element.

Section X. AIR VENTS

4-47. General.

Air vents installed on radiators and ends of mains of gravity heating systems consist of a combination thermostatic and float actuated valve stem and orifice, usually housed in a sealed casing. Some air vents include an adjustable orifice to increase or decrease the vent rate, which provides for balancing of the heating system.

4-48. Installation and operation.

Vents, when installed on radiators, are located at the end opposite the steam connection. Radiators for use with steam and hot water often have two vent tappings, one near the top and the other approximately one third of the way down from the top. The lower opening is used for steam systems, since this is the location at which air will pocket between the top and bottom radiator section connections. The top opening is used to vent the radiator in hot water systems. Vents at ends of steam mains, unit heaters, and the like are usually of the vertical straight shank type and are installed at the top of a vertical pipe extension. The usual type vent is sealed so that on-the-job repair is not practical. Therefore, when placing a vent in initial operation, be careful not to force or inject excessive amounts of grease or scale into the vent.

4-49. Maintenance.

Remove vents from the system during the off-heat season and allow to soak in a container of kerosene for approximately 24 hours to loosen rust and grease; then place in a vertical position, drain thoroughly, and allow to dry. Air pressure is very effective in blowing out vents following the kerosene soaking process. When using air pressure for removing dirt, use proper goggles for eye protection.

4-50. Typical operating difficulties.

The most apparent failure occurs when a vent spouts water and steam caused by dirt on the valve or opening, by failure of the thermal element or by a bent connection in a water pocket of the piping system. A clogged vent could result in air binding which would prevent steam from entering the heating unit. If unsatisfactory vent performance cannot be corrected by cleaning procedures, replace the vent. Manufacturers usually maintain a repair service; consult the manufacturer for details of factory servicing of vents when a quantity of defective units have accumulated and repair is beyond the scope of local repair facilities.

Section XI. STEAM RADIATORS

4-51. General.

There are two types of radiators: cast iron and extended surface units. Extended surface units are made up of relatively small tubes onto which metal fins are formed. The tubes of extended surface units are either continuous or set in headers and the tube element is placed in a metal cabinet or enclosure with circulating grilles at the top and bottom.

4-52. Installation.

It is extremely important that radiators pitch toward the condensate discharge opening, particularly if the radiator is of the extended surface type. Radiator traps applied to extended surface radiators must be in perfect operating condition; slight holdup of condensate will greatly reduce the effectiveness of this type of heating unit which has relatively small available steam space. Traps of extended surface radiators are placed at an elbowed down connection, so that the trap is below the steam space to facilitate cleaning. Swing-through double-elbow joints should be used and ample length in supply and return branches to radiators should be provided so expansion and contraction of mains will not cause breakage of radiator connections. Cast iron radiators require a firm setting on solid flooring; legless radiators are firmly fixed to wall brackets. Radiators are normally installed directly under windows or at outside walls to offset transmission and infiltration losses and provide comfortable room conditions. Reflectors can be provided behind radiators to get maximum heat output, covering them should be avoided.

4-53. Initial operation and cleaning.

After new radiators have been in service for a short time, open and clean out thoroughly through the return opening. Clean the outside of radiators frequently to maintain maximum heat output.

4-54. Typical operating difficulties.

Failure to heat due to stoppage or defective piping causes radiator operating difficulty. Air binding will also prevent radiators from heating properly. See Section X on air vents. If radiators heat but no rise occurs in room temperature, calculate the room heat loss and compare it with the quantity of installed radiation. Reduce heat loss, if possible, by stopping cold air leaks through cracks, doors, and windows of the area being heated. If radiator output is still insufficient, relocate radiation units or install additional units.

Section XII. STEAM UNIT HEATERS

4-55. General.

Unit heaters consist primarily of an extended surface steam coil and a propeller or blower fan which creates rapid flow of air through the heating coil. The basic types are horizontal and vertical discharge from ceiling suspension (figures 4-27 and 4-28) and floor mounted horizontal blower units (figure 4-29). Units are rated in BTU per hour or equivalent direct radiation (EDR) heat output and cubic feet per minute air discharge capacity at given motor or fan speeds. These ratings are important in application of unit heaters. The area effectively heated by the unit is reduced as the elevation of the unit is increased. It is preferable to set the horizontal discharge to blow toward an outside wall at a large angle and to discharge all units in the same direction to form a continuous circuit of air around exposed walls. Units placed in small rooms with low ceilings may be located on outside walls with a recirculating duct to the floor to provide even heating effects without undue draft conditions. Vertical discharge units are usually placed at room ceiling or structural members and, since they discharge directly downward, appropriate diffusing type outlet nozzles are used to eliminate drafts or hot spots at the floor level.

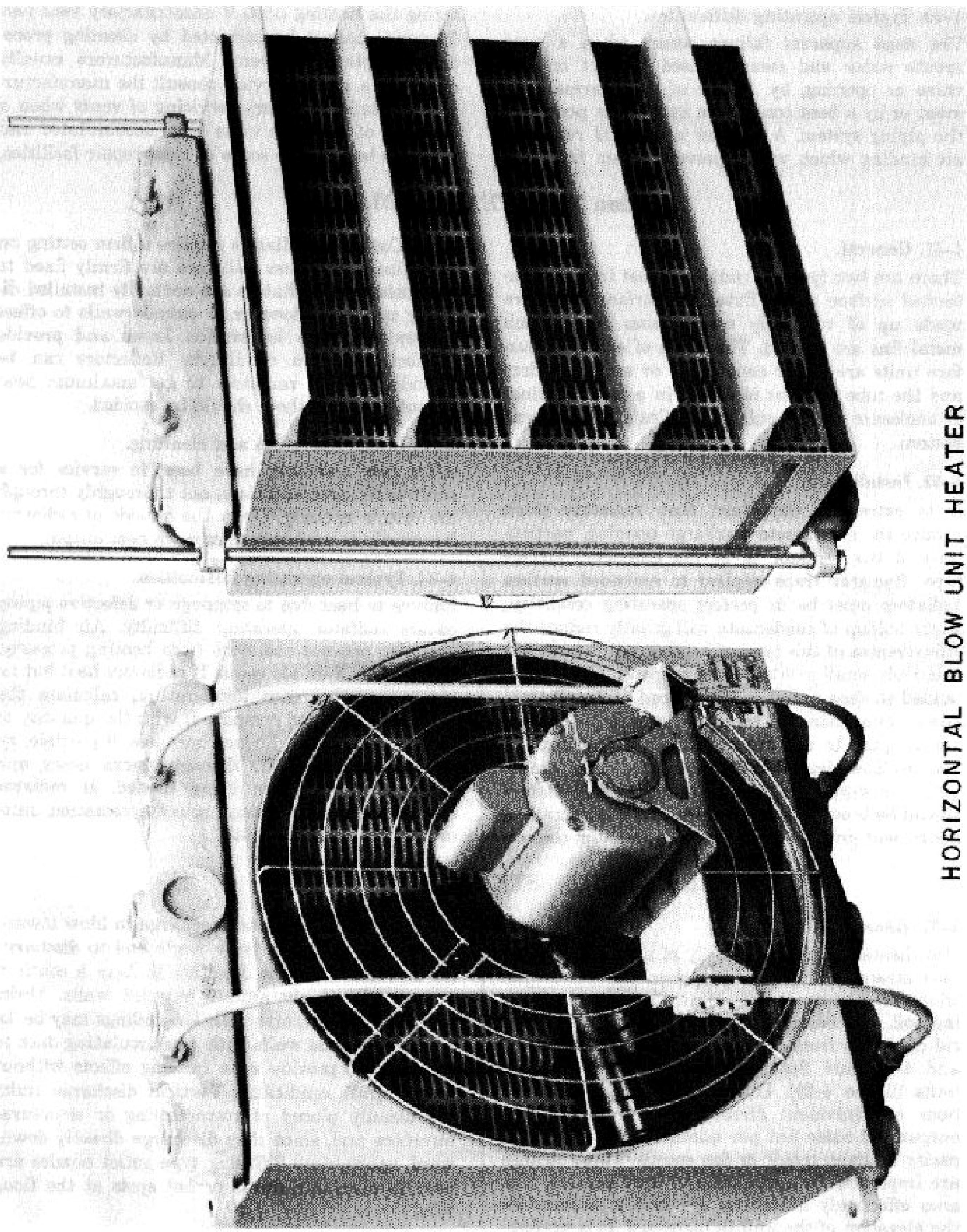


Figure 4-27. Horizontal-blow unit heater.

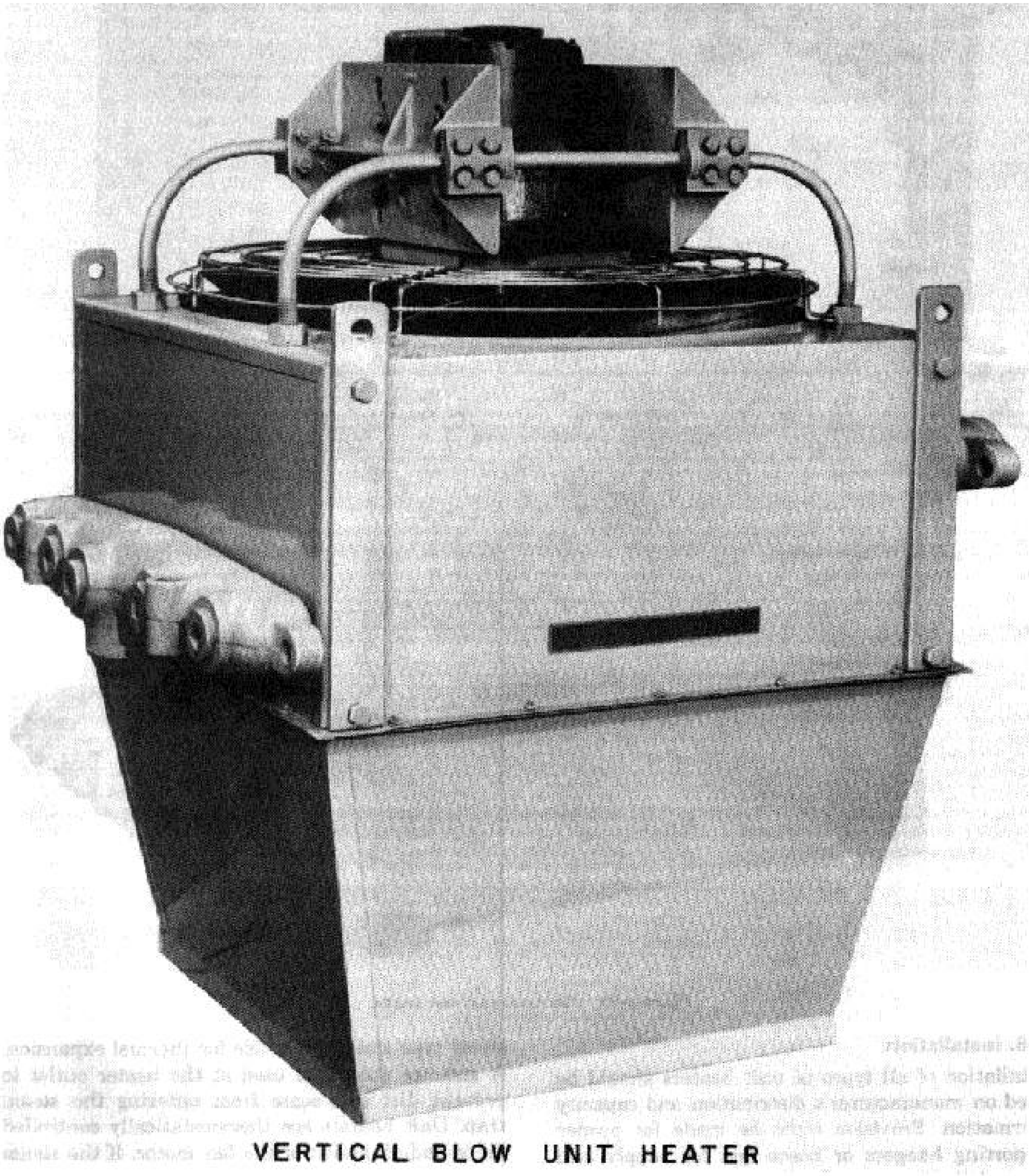


Figure 4-28. Vertical-blow unit heater.

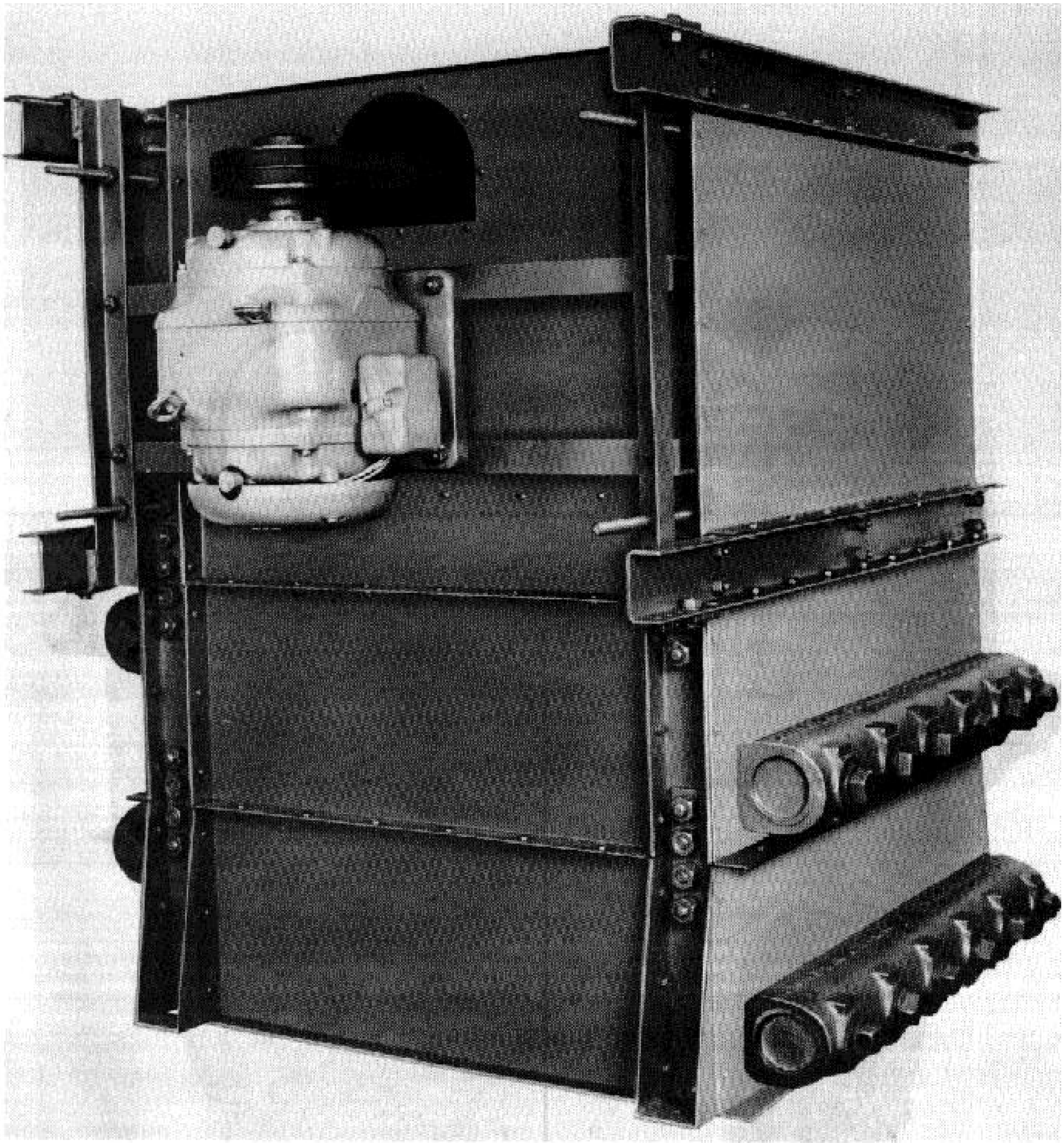


Figure 4-29. Floor mounted unit heater.

4-56. Installation.

Installation of all types of unit heaters should be based on manufacturer's distribution and capacity information. Provision must be made for proper supporting hangers or bases and for supply and return branch connections with ample pitch and drop. Steam piping should have double elbow swing type joints to provide for thermal expansion. A strainer should be used at the heater outlet to prevent dirt and scale from entering the steam trap. Unit heaters are thermostatically controlled by on-and-off action of the fan motor. If the steam system has periods when no steam is supplied, thermostatic controls include a reverse acting immersion or surface aquastat or a pressurestat which permits operation of the unit heater only when steam is available. When starting a cold heater, condensate forms rapidly at rates beyond normal heater capacity. Therefore, adequate drop shall be provided between the heater outlet and connection to the return main, and a trap of sufficient capacity should be provided to handle the initial condensate flow. If the piping system is of the two-pipe open return type without traps, the unit heater coil is vented adequately by extending a vertical pipe from the point at which the unit return branch drops to the return main. An air vent is placed at the top of the vertical extension and should run to a point above the top of the heater.

4-57. Maintenance.

Check electrical connections and contacts periodically, lubricate bearings, and clean out piping connections and strainer. Clear the outside of the steam coils as required. Replace fan guards on unit heaters after maintenance.

4-58. Typical operating difficulties.

Spaces may fail to heat satisfactorily even though the unit heaters appear to be hot and steam is available. Check the unit heater motor and fan speed to be sure that heated air is passing through the unit in sufficient quantity to provide the required capacity. If units are delivering their design capacity, check the space heat loss, and check to see if the location of the heaters is proper. There are horizontal and vertical distance limits which affect the performance of unit heaters. Review manufacturer's literature to determine if the heating failure is due to excessive height or distance between units. Failure of units to fill with steam is usually due to failure of the air venting device, clogged piping or inadequate trap capacity.

Section XIII. STEAM HEATING COILS

4-59. General.

a. Extended surface coils similar to those used in unit heaters, but of considerably greater capacity and physical dimension, are used extensively in heating air for fan blast heating systems and ventilation systems. Coils usually consist of non-ferrous tubes onto which fins are forced to provide large surface area. Steam heating coils are of four general types:

(1) Serpentine coils are used for small steam heating jobs with low air quantities where there is no possibility of the coil freezing. In these coils the steam is introduced at the top where it flows in a serpentine manner to the outlet at the bottom.

(2) On larger installations header type coils are used where steam is introduced into a large header which feeds a number of small tubes in parallel. The steam may then make one or more passes to a return header which collects the condensate and is provided with a connection at the bottom which is piped to the steam trap.

(3) Another type of coil uses a small perforated tube nested within a larger tube. The steam enters a header into which a number of these tube assemblies are connected. The header is split and arranged so that the steam flows into the inner tube and the condensate flows around the inner tube, back to the condensate portion of the header to be drained away. The design purpose is to keep the condensate warm so that it will not freeze. The original selection of the name "non-freeze" coil was unfortunate because too many have experienced freeze-up, usually because of failure of the trap to drain the condensate.

(4) On all of the above types of steam coils the control is by means of a thermostat modulating the steam flow to the coil to match the load. A fourth type of coil is the face and bypass coil where steam is delivered to a top header and condensate removed from a bottom header. When in operation the steam is on at full pressure and control is obtained by means of the thermostat operating face and bypass dampers around each tube. Properly installed, this coil is the least subject to freeze-up on 100% outdoor air installations.

4-60. Installation.

Provision must be made for ample support and ample pitch to assure quick drainage of condensate. Ample pitch is particularly necessary when long coil are used, since the cross-sectional area of each tube is small. Small quantities of condensate formed due to lack of pitch will reduce the heating capacity considerably. The discharge or return connection should be dropped approximately 12 inches before entering the trap to ensure proper drainage. Large slugs of condensate from cold units are handled by traps of adequate capacity. Long coils are tapped for air venting and provided with auxiliary air venting units and vacuum breakers when required. Manufacturer's piping details indicate tappings to be used for steam supply, condensate return, air venting and general installation requirements.

4-61. Initial operation and cleaning.

Clean the steam system piping before connecting heating coils to the system, since small amounts of oil, grease, or core sand can close tubes of extended surface radiation completely. Drain and blow out coils periodically to eliminate stoppages due to accumulated foreign material.

4-62. Maintenance.

Service traps and adjust steam supply controls to assure complete filling of coil with steam and rapid removal of condensate. Maintain the air side of coils in a clean condition to maximize heat transfer.

4-63. Typical operating difficulties.

Complete or partial failure of the coil to heat properly can be caused by lack of sufficient steam pressure, faulty operation of the inlet control valve, or defective traps, vacuum breaker or air vents. Improper pitch results in greatly reduced heat output. Failure of the coil to heat properly may also be caused by a restriction in airflow caused by a dirty coil, dirty filters, or a restriction in the ductwork. Improper fan speed will also reduce the amount of air going through a coil which reduces the coil output.

Section XIV. STEAM HUMIDIFIERS

4-64. General.

a. To ensure the advantages steam affords over other humidification media, the humidifiers employed must provide three essential performance characteristics: conditioning, control, and distribution. The humidifier must condition the steam to be completely dry and free of significant particulate matter. It must respond immediately to control and provide precise modulation of the output. Finally, it must distribute steam as uniformly as possible into the air. Direct steam humidification can be used only when the steam supply does not contain toxic chemicals such as amines. Heat exchangers should be used whenever there is any question about the quality of the steam.

b. Proper location, installation, and control of humidifiers are essential to achieve totally satisfactory, troublefree performance. The primary objective is to provide the required humidification without dripping, spitting, or condensation. Moisture, even in the form of damp spots, cannot be tolerated in the system. Aside from the hazard to the structure caused by water in the ducts, there is an even more critical health hazard if breeding grounds are provided for bacteria.

c. Steam must be discharged as uniformly as possible into the air to permit the fastest possible absorption without creating damp spots or saturated zones. In normal ducts, a single distribution manifold installed across the long dimension will provide good distribution of steam. In large ducts or plenum chambers, it may be necessary to broaden the pattern of vapor discharge to achieve the required distribution, thus requiring multiple manifolds from a single or from multiple humidifiers.

d. Humidification for areas not having central air handling systems is customarily achieved with unit humidifiers discharging steam directly into the space. Proper mixing of the steam with the air is accomplished by use of a dispersing fan mounted on the humidifier, or by installing the humidifier in conjunction with a unit heater, positioned such that the air flow from the heater absorbs and distributes the water vapor.

4-65. Installation of duct type humidifiers.

a. Horizontal manifolds should be perfectly level with the discharge holes pointed upstream against the air flow. Manifolds over one foot in length should be supported. The humidifier body is normally suspended by straps or mounted on brackets, and should be mounted right at the duct or fan housing.

b. Steam supply and condensate drainage piping should be made in accordance with good piping practice. The use of multiple vertically-stacked manifolds from one or more humidifiers should be considered when any of the following conditions exist at the humidifier location:

(1) If duct air temperature is below 65F.

(2) If duct air velocity exceeds 800 FPM.

(3) If high efficiency filters are located less than 10 feet downstream.

(4) If the height of the duct section exceeds 36 inches.

(5) If visible vapor impingement on coils, fans, dampers, filters, turning vanes, etc. located within three feet downstream of the humidifier would be objectionable.

c. Humidifier manifolds should be located according to the following guidelines:

(1) Whenever possible, install the distribution manifold downstream from the coils. If there is more than three feet between the manifold and the coil on the upstream side, the manifold can be

installed at this location.

(2) When it is necessary to place the humidifier in the coil section ahead of the fan, locate the manifold in the most active air flow and as far upstream from the fan inlet as possible.

(3) When it is necessary to place the humidifier discharge into a packaged multizone air handling system, install the distribution manifold into the center of the active air flow and as close to the fan discharge as possible.

(4) Do not install a distribution manifold closer than 10 feet upstream from a temperature controller.

(5) The distribution manifold should never be placed within three feet of a fan inlet; the best location is at the fan discharge.

(6) Whenever possible, install the distribution manifold into the center of the duct.

(7) Always install distribution manifolds as far upstream from discharge grilles as possible, never less than three feet upstream.

(8) Always size and install the distribution manifold to span the widest dimension of the duct section.

(9) The manifold should never be installed vertically downward from the humidifier. This presents a condensate drainage problem in the jacket of the manifold. Vertical upward installation is permissible.

4-66. Installation of unit humidifiers.

Unit humidifiers are installed very much like unit heaters. They may be suspended from the ceiling or bracketed to a column in locations determined as best for achieving uniform distribution of water vapor. The humidifiers should be mounted high enough from the floor so that discharge clears personnel and far enough from the ceiling to prevent condensation; discharge should not impinge upon machinery, columns, light fixtures, piping, etc.

Section XV. PRESSURE REDUCING VALVES

4-67. Types.

Space heating systems connected to a high pressure central heating plant and distribution system have pressure reducing valves which reduce the main pressure to low pressure heating service. There are many types of steam service reducing valves, including double-seated or single-seated, diaphragm-loaded or spring-loaded, or combination spring and diaphragm loaded, and many types of special pilot operated valves. The most applicable valve for reduction of 50 to 75 psig initial pressure down to 5 psig is the double-seated diaphragm-loaded type (figure 4-30). The diaphragm chamber is connected to the low pressure steam heating main by an equalizing pipe. The equalizing pipe is connected to the steam main approximately 10-15 feet from the valve at which point steam pressure is considered stabilized. Valve setting on the low pressure side is obtained by adjusting a system of springs or by weights on a lever arm. Range of accurate reduction through a pressure reducing valve depends on the type of valve seat and power of leverage and control element. A double seated diaphragm and lever operated valve will provide satisfactory service to a maximum of 75 psig upstream pressure. A small amount of continuous steam leakage usually occurs through double-seated valves, since it is difficult to obtain two tightly seated disks on the same stem for use under varying temperature conditions. Therefore, in steam pressure reduction where tight shutoff is required, as in providing steam for kitchen equipment and sterilizers, a single-seated valve is used. Slight leakage of a double-seated reducing valve in heating system service is not serious since space is available for quick condensing and discharge through traps into the return system.

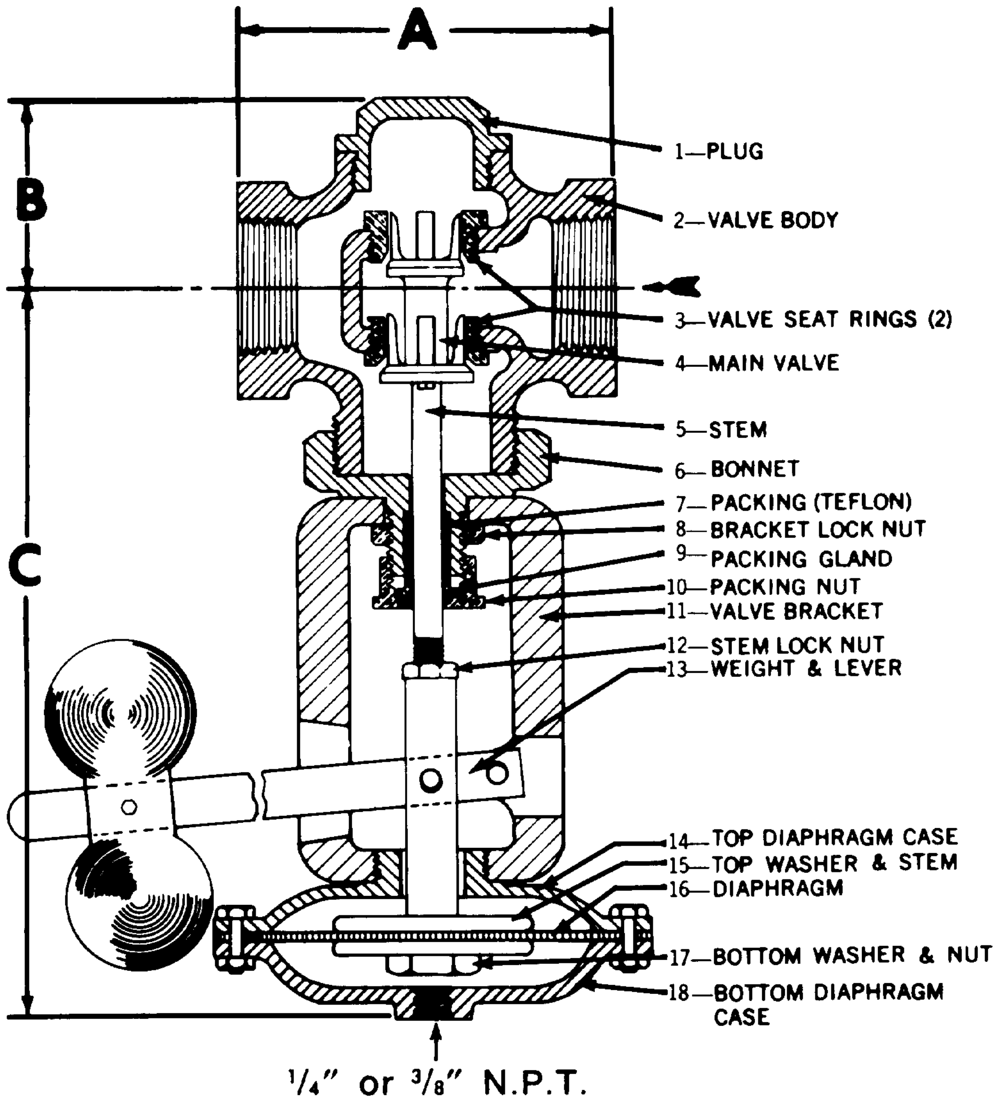


Figure 4-30. Double-seated diaphragm pressure reducing valve.

4-68. Installation and initial operation.

The branch leading to the pressure reducing valve (PRV) is a top connection from the main steam line. Every precaution should be taken to ensure delivery of clean, dry steam to the valve. The reducing valve installation includes a strainer ahead of the valve, a globe valve ahead of the discharge, and a gate valve in the discharge; all are bypassed by a line one size smaller than the pressure reducing valve. (See figure 4-31 for a typical PRV schematic arrangement.) Generally, a straight-through size provides more satisfactory steady pressure reduction than an expanded outlet valve, giving a more stabilized interior operating condition. A typical low pressure diaphragm valve is installed so that the diaphragm is below the valve. The diaphragm chamber is connected to low pressure steam main by a ½ or ¾ inch pilot line which connects to the main at a point not less than 10 feet from the valve. Pilot lines are valved at the connection to the main, and contain a capped or valved cleanout connection, and an accumulation tank or fitting connected so that it always contains enough condensate to fill the diaphragm chamber. The accumulator is arranged so that condensate is not siphoned from the pilot line when the low pressure steam main is under vacuum pressure when the system is shut off. A steam gauge is provided in the low pressure main not less than 10 feet from the valve, at which point pressure is generally stabilized. The low pressure side of the PRV installation also includes a pop-safety or pressure relief valve.

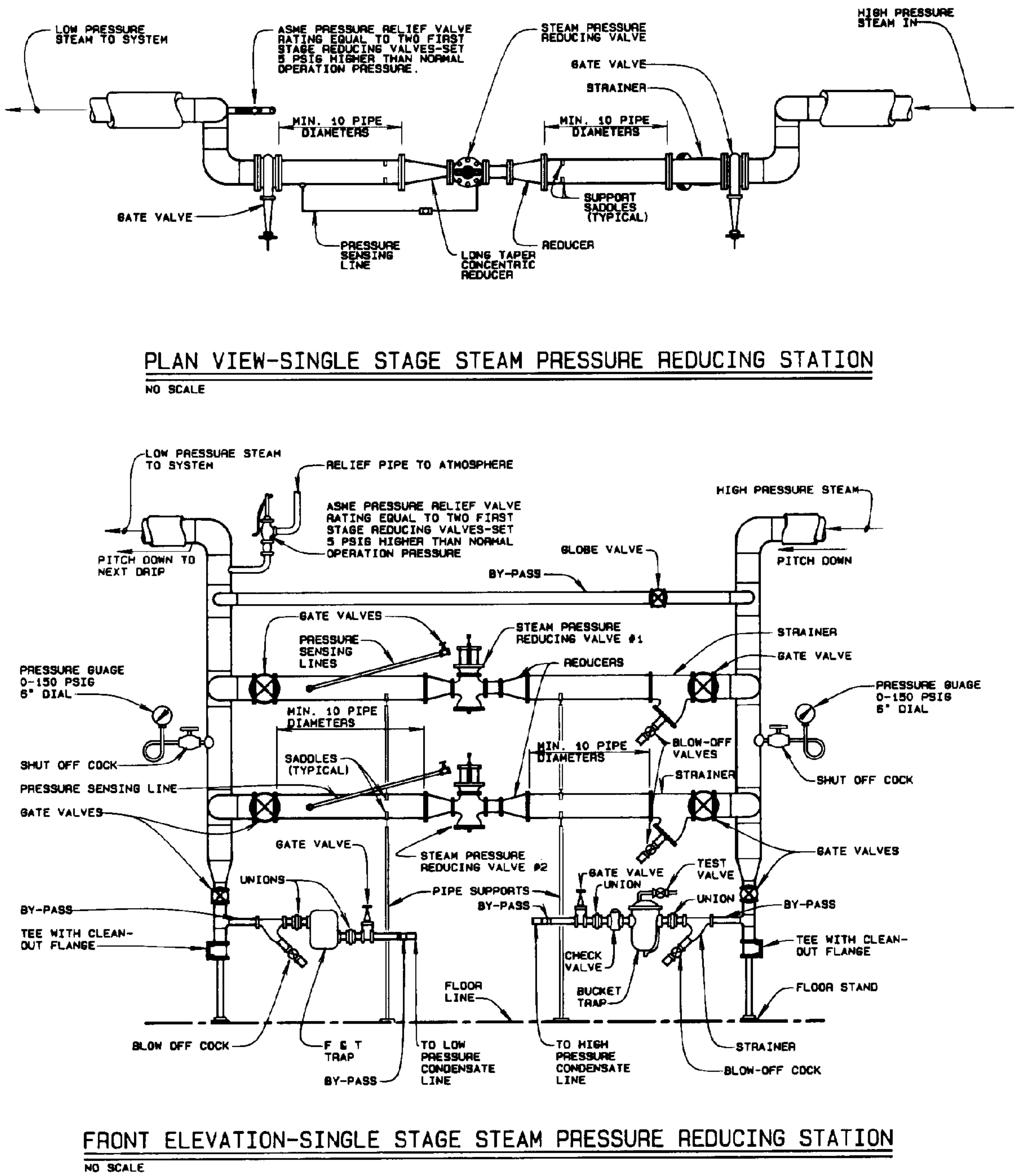


Figure 4-31. Steam pressure reducing station.

4-69. Operation and maintenance.

Fill the pilot line with water to avoid steam damage to the diaphragm, set the lever weights or spring load at the desired low pressure, and, if the piping system is new, clean the strainer preceding the valve several times. Maintenance will be at a minimum if clean dry steam is supplied. Periodically check the valve and seats for wear and cutting and also check the diaphragm. Unless a shop is well equipped to grind in new seats and valves, the valves should be overhauled by the manufacturer or by a specialized valve repair shop if replacement of valves or seats is required. When wear is excessive, carefully check the condition of steam supplied for quality and contamination by foreign matter.

4-70. Typical operating difficulties.

Failure of the pressure reducing valve to control pressure is caused by improper sizing, plugging of the pilot line between the valve diaphragm and low pressure steam main, diaphragm failure, cut seats and valve heads, binding of the valve stem, or incorrect adjustment of the weighted lever or spring control tension. Examine the valve stem and replace, if necessary. Change or regrind the valve and seat as required. Cut seats and valve heads indicate an oversized valve.

Section XVI. GENERAL PROCEDURES FOR OPERATION AND MAINTENANCE

4-71. General.

Although vacuum, gravity, and vapor system installations are alike in operating principle, it is seldom that two installations will be alike in installation details, such as location of valves, dampers, header and piping connections. It is therefore, important to examine and check an installation before taking over operation of a new system. New operators should check the pertinent details of an existing installation when taking over the responsibility of its operation. Well defined procedures for operation of high pressure boilers, because of the hazards involved, are stressed by insurance and safety organizations. Property damage and injury to personnel can also occur when low pressure heating equipment fails. Proper functioning of mechanical equipment is possible only when equipment has been properly installed and placed in service. The operating and maintenance organization should have a knowledge of proper installation and initial start-up procedure. Detailed installation instructions, dimension prints, operating instructions and maintenance procedures are made available by most manufacturers and should be used and made a part of the equipment or operating file.

4-72. Valves and piping.

Inspect all system piping carefully; determine that it is free of leaks, properly pitched in the direction of flow, and free of stoppages due to oil, grease, and other foreign matter, and that drip and vent connections and accessories such as drip traps and air vents are in proper operating condition. Note the location and function of all valves, particularly those in the boiler room, and check them for proper operation. The condition of valves is important and should be determined before needed for use in emergency conditions. The opening of bypass valves through the system, by building occupants or others unfamiliar with their purpose, results in considerable operating difficulty. This should be considered when difficulties are due to excessively hot return lines. Bypasses around traps, reducing valves, control valves, and pumps should be tightly closed except during emergency repair periods. It is of extreme importance that the layout of the boiler feed system and its pump connections, water line regulators, automatic feeders, and make up water connections be clearly understood. When a boiler is in operation, pull the popsafety valve to determine that it is free to open. Test this valve periodically under boiler pressure to determine that it is properly set. Check hangers, anchors, expansion bends or joints to determine that piping weight is properly distributed and that hangers and rollers are free to permit movement of piping from expansion and contraction.

4-73. Water level.

The most important item to note in boiler operation is maintenance of a proper water level in the boiler. Too low a water level may result in permanent damage to the boiler. Too high a water level will cause delivery of wet steam and carry over of slugs of water which will result in system failure and the possibility of piping breakdown as a result of water hammer. Determine the proper water level for the particular installation and be certain that it is maintained at all times. Do not depend on automatic devices as an assurance that water level is being maintained. Observe water level in the gauge glass frequently during each operating shift, particularly when taking over a shift. If the water level fluctuates, determine the cause immediately and take corrective action.

4-74. Combustion equipment and controls.

Operating efficiency can be obtained only when firing systems and controls are functioning properly. If the system is hand fired, (coal) determine that grates are free to operate and clear of clinkers, and that the ash pit does not contain excessive accumulations of ash or other foreign material. Control of hand fired units usually consists of a pressure actuated damper regulator, with connections to the boiler draft damper and a check damper located at the smoke outlet. Be sure that damper chain connections are in place and that pulleys or other guides permit free movement of chain connections, and that the regulator is properly set and in operating condition. If the boiler is automatically fired, determine that fuel storage is being adequately filled and that fuel and air adjustments are correct. Determine also that electrical connections, line switches and fuses are of the correct rating. Check controls periodically, particularly for the cut-in and cutout point of the pressure limit switch, and the cutout point of the low water cutoff switch.

4-75. Boiler structure.

Inspect the general condition of the boiler setting and covering, to be sure that setting is free of air leaks, and in good structural condition. Inspect exposed surfaces, particularly the crownsheet and interior surfaces of the combustion chamber, and the lower areas at the mud ring for water leaks and corrosion. The surfaces on the fire side should be inspected often to determine that firing procedures are correct and are not causing excessive sooting and that surfaces are cleaned as required. Open the bottom drain valves periodically to flush out scale, grit, and other foreign matter which, if allowed to accumulate, results in boiler burn out and other serious damage.

4-76. Housekeeping.

Keep the boiler room clean and tools properly placed. A disorderly, cluttered boiler room constitutes a definite hazard to personnel safety and is a detriment to proper maintenance and operating efficiency. The floor should be clean at all times and kept clear of water and loose tools and materials. Accumulated material is a serious fire hazard.

Section XVII. TYPICAL STEAM HEATING OPERATING DIFFICULTIES

4-77. Water level fluctuation.

a. Rapid fluctuation. Rapid cycles of water level rise and fall or a bouncing water level, is usually caused by grease and oil in the boiler. The grease and oil form a film on the surface of the water and cause rolling of water which is released in slugs with the steam. Excessive firing rates cause high steam release rate with entrained moisture or excessive steam velocity through boiler outlets which may siphon water from the surface and produce a bouncing water level. Gauge glass connections placed at very active circulating points of the boiler result in siphonic or forced flow action in the water column; this gives the appearance of fluctuating water level, though the actual boiler water level is satisfactory. The water level may be too high, causing siphon action or carry-over of boiler water.

b. Slow fluctuation. Slow rise and fall of the water level in single boiler installations is usually due to a vacuum or condensate pump returning condensate in excessive quantity at each feeding cycle. This occurs when the distance between receiver water levels at pump cut-in and cut-out is too great. This condition can also be caused by water which is forced out through return connections of gravity systems owing to failure to equalize as the result of long runs of mains or by an excessive initial steaming rate. In multiple boiler installations, water may be higher in one boiler because of an uneven firing rate.

4-78. Low water level.

Low water level is the most serious situation that may occur in a boiler plant. Automatic water feeders should not be depended upon for assurance of proper water level, as accidents to piping may result in instantaneous make-up water demand beyond the capacity of the feeder. When low water level is detected, shut off automatic firing equipment immediately or open firing doors and shut off draft of hand fired boilers to cool the boiler gradually. *Do not open cold water make up lines.* After the boiler has cooled, proceed to determine the cause of water loss. Low water level indication may be due to any of the following causes:

a. Water-gauge glass either shut off manually or water drained from the glass.

b. Broken boiler sections or excessive leak in steel boiler.

c. Pump failure or broken return main from system to pump or valve at pump inlet shut-off.

d. Broken or stopped up pump discharge line to boiler or return valve at boiler shut-off.

e. Excessive oil, grease, and foreign matter in boiler water resulting in excessive priming.

4-79. Loss of pressure.

a. If pressure fails, check for the following possible causes:

(1) Inadequate firing rate or poor combustion condition, insufficient draft, soot clogged boiler passages and breeching, or inadequate air supply to the boiler room.

(2) Dirty boiler including either scale on water side, soot on fire side, or both.

(3) Broken main causing excessive loss of steam.

(4) Steam load in excess of boiler capacity.

(5) Oil or grease in boiler water.

(6) Steam gauge may be defective, not properly indicating actual pressure conditions. Open test

cocks and note if steam pressure is available regardless of gauge indication.

b. Do not confuse pressure failure with a condition under which closed vapor or vacuum systems may be circulated under negative pressure or vacuum because of temperature or other controls which cause a low firing rate, balanced with low space heat demand. Induced vacuums will occur when the radiator condensing rate exceeds the boiler evaporation rate.

4-80. Pounding in the system.

This should not be confused with snapping which occurs when expansion takes place at initial heating up of systems. Pounding or water hammer is caused by slugs of water which are carried at high velocity with steam and which may have sufficient force to break piping, in addition to creating excessive noise. Existence of water slugs in steam piping is the result of:

a. Carry-over through the boiler nozzle due to excessive steaming rates, priming due to grease and oil in water, or the water level being too high.

b. Condensate trapped in piping system because of sagging mains and pockets; plugged and faulty steam main drip connections.

c. Air bound mains due to defective vents which trap condensate behind the air pocket.

4-81. Heating unit malfunction.

This is basically a failure of the steam space of the radiator, coil, or steam chest to fill with steam and is due to:

a. Inadequate steam pressure.

b. Defective valve (in which the disc may have fallen onto the valve seat), valve plugged with scale, or failure to open.

c. Air bound radiator caused by defective air vent or trap.

d. Water logged radiator caused by defective trap.

e. Discharge connection pocketed or rising from unit causing flooding of unit.

f Traps of inadequate capacity.

g Heating coils of excessive length and height may fail because of air binding and should be provided with vent connections and/or vacuum breakers in accordance with the manufacturer's recommendations.

h. Inadequate pitch of the heating element or radiator will cause faulty 'drainage and failure to heat. This is particularly marked in small horizontal extended surface, fin-tube radiation.

4-82. Failure of space to heat.

If space heating units such as unit heaters or blast systems are filled with steam, the ductwork and fans should be checked for air delivery and distribution. Lack of heat may be caused by fan motors which are running under speed or by reduction of duct capacity due to closed or partially closed dampers. Heating failure and lack of proper distribution often occurs in large spaces such as aircraft hangers and work shops, caused by the inability of unit heaters located too high above the floor, to force air to the work space. Stratification of heated air at ceilings in such installations may be overcome by use of recirculation ducts which have floor inlets and which connect to the inlet side of the unit heaters. Also, check the heat loss of the space; be sure to include the load imposed by an exhaust air system and compare the load with the capacity of installed heating units.

4-83. Pump venting steam.

Do not confuse this with low temperature vapor or moist air discharged from pump vent. Steam venting from condensate or vacuum pumps is caused by leaking traps, open bypasses around traps, or backup of high temperature boiler water into the pump due to leaking check valves in the pump discharge line. High temperature water is present in the pump when steam is observed to be venting from the pump. This may result in vapor binding of the pump. If the pump is a vacuum type it will fail to create a vacuum at excessive condensate temperatures. When steam discharges from vents of vacuum pumps or high condensate temperatures exist, the pump should be placed on float control. If allowed to remain on vacuum control, the pump will run continuously and will accomplish no useful purpose. If check valves in the pump discharge line leak, the pumping units will cut in frequently and cut out for relatively short periods, depending on the rate of boiler water backflow into the pumps.

4-84. Pump venting water.

If water is venting from the pump check, consider the following possible causes:

a. Pump capacity, volume or discharge pressure of pump, is inadequate. Determine the discharge pressure at the pump outlet by installing a pressure gauge at this point and checking with manufacturer's performance and capacity charts or curves. Open the return connection to the pump and measure the rate of condensate flow to determine the quantity to be pumped.

b. Pump may be rotating in wrong direction. This can be readily determined by touching a rubber tipped pencil to the shaft. Note the direction of rotation and compare with manufacturer s drawing or, if present, the direction arrow mark placed on pump casing.

c. Pump control may be failing to cut in pump at proper receiver level.

d. Pump impeller may be worn or clearances may be too great, reducing discharge capacity of the pump.

e. Outlet valve of pump or discharge line may be clogged.

f. If the pump is controlled by a float controller at the boiler line and equipped with a float controlled makeup water valve at pump receiver, the makeup valve may be leaking or set too high. Under these conditions the pump may cut in and satisfy the boiler water level with makeup water, followed by condensate returning to the pump in large volume with no demand for boiler water level replacement, which results in overflow of the receiver. This can be corrected by adding an auxiliary receiver above the pump receiver to take care of overflow, or by changing the control system to a standard pump receiver level control in place of the boiler water level control.

4-85. Steel boiler failure.

If a steel boiler burns out or leaks, check for the following possible causes:

a. Low water level, particularly if the failure is in the area of the crown sheet.

b. Failure in lower area of combustion chamber. This is usually caused by accumulation of mud, scale and other foreign matter in the mud ring area which results from improper cleaning and blowndown.

c. Corrosion on the fire side of the boiler caused by improper layup or cleaning.

d. Interior corrosion caused by improper layup or water conditions.

e. Leaks at tube ends, drain openings, and manholes will, if not corrected immediately, result in corrosion of adjoining plates.

f. Improper suspension or expansion provisions of headers and piping if leaks or fracture occur in the area of boiler connections.

4-86. Cast iron boiler failure.

If a cast iron boiler cracks, check for the following causes:

a. Check water line conditions.

b. Excessive firing rates may cause “dry spots” in the water side of the boiler, particularly if water contains oil, grease, and other foreign matter. Check for faulty circulation in narrowed drop sections or baffles at the rear of the combustion space.

c. Header connection may not be properly arranged to permit expansion and contraction of header and system connections. This usually results in fractures in the area of the header connections.

d. Staybolts too tight to permit expansion and contraction of sections.

e. Accumulation of soot and scale which work into the space between sections and result in growth and expansion, which may break sections.

f. Excessive feed of cold water to a hot water boiler may cause failure.

4-87. Boiler room smoke.

Presence of smoke and combustion gases in the boiler room is a serious condition. Combustion gases such as carbon monoxide may be created wherever there is incomplete combustion of gas fuel, generally, because of inadequate draft in a gas appliance or a leak in the furnace’s heat exchanger. When such conditions exist, corrective measures should be taken immediately. Check for the following possible causes:

a. Check for a closed boiler outlet damper or stoppage of the breeching or stack.

b. Check to see that the tube or gas passages of the boiler are not closed by an accumulation of excessive soot and fly ash.

c. Determine that sufficient door, window, or other openings are in use to permit air necessary for combustion to enter boiler room.

d. Leaky settings or breechings will permit gas leakage to the boiler room during periods of positive pressure in the combustion chamber. Check the boiler settings for leaks by using a candle to note suction at surface cracks and joints when the boiler is under negative pressure.

e. Stack or breeching may be inadequate.

f. Breeching may have too many sharp turns, or may pitch downward and reduce the effective area.

Section XVIII. SUMMER LAY-UP PROCEDURES

4-88. General.

Most damage to and deterioration of heating equipment occurs during summer and other lay-up periods because of careless or inadequate procedures in placing equipment on inactive basis. During these periods excessive rusting, corrosion, and grease clogging occurs. If the idle period includes periods of freezing temperature, incomplete drainage will result in damage from freezing. Well planned procedures must be followed in placing heating systems in proper condition for standby.

4-89. Draining system.

Drain all steam and return lines of condensate completely by opening drain valves at pumps or return connections in the boiler room, and by opening the drain or dirt pockets located at ends of mains and at other drip points in the building piping system. Particular care must be taken to assure proper draining of wet returns and loops under doorways. During draining operations, it is important to determine that piping is properly pitched and that no low points or pockets which can accumulate water are present. This is particularly important in servicing wet return lines. Mains under basement floors should be opened at both ends and blown out with compressed air. Leave drain points open during lay-up to permit air movement and reduction of sweating. Threads of drain plugs, caps and other similar pieces of equipment should be carefully brushed clean of rust and other debris, thoroughly coated with oil and tied to the drain point to be readily available for reinstallation at the start of the heating season. Drain openings should be covered with a single layer of cloth to prevent entrance of rodents and foreign matter. If drainage through available drain points is inadequate, disconnect intermediate unions to assure drainage of piping. Also note condition and exposure of outdoor mains to assure that they will not be damaged by outside weather conditions or by accumulated water in pits, conduits, and tunnels.

4-90. Boiler cleaning and lay-up.

At the end of the heating season, boilers should be opened, thoroughly washed internally, and laid up so that the water side and fire side are free of corrosive material. All personnel engaged in boiler cleaning and spraying should be provided with proper respiratory and eye protection, and suitable protective clothing. The following methods are recommended for lay-up of boilers.

a. Cast iron boilers.

(1) Clean boiler thoroughly and remove grates, if applicable, to facilitate access and inspection. Use wire brushes to remove all soot, dirt, and scale from flues and firebox surfaces. Open boiler drain plugs at the front and rear of boiler. If drain is not present, open the return header and thoroughly wash out the boiler using a hose with water at sufficient pressure to loosen mud and accumulated sludge. Complete removal of accumulated foreign material in the lower sections of the boiler or mud ring is of extreme importance.

(2) Spray flue surface with light lubricating oil, using an oil gun with an extended stem and bend end, so as to reach all corners and crevices. Used crankcase oil is unsatisfactory for this purpose.

(3) Remove all ashes and unburned fuel from the grates and ashpit of hand fired coal burning boilers.

(4) Clean the smokepipe and remove it during the summer, if feasible. If controls are mounted in the smokepipe be careful not to disturb them.

(5) Leave boiler doors and dampers open during the lay-up period. This will permit air movement through the setting and will help prevent sweating on the inside of the boiler while not in use.

(6) Oil hinges of all doors and moving parts of regulators.

(7) On hand fired boilers replace warped, broken, or worn out grates which, if not serviced, would permit unburned coal to drop into ashpit and would also affect proper combustion during the heating season.

(8) Tie rod nuts should be removed and replaced with spring washers and safety nuts to permit safe expansion conditions.

(9) Cast iron steam boilers, following cleanup of the boiler at the end of heating season, should be completely filled until the start of next heating season.

(10) If an automatically fired steam boiler is operated during summer months for operation of submerged type domestic water supply heaters, maintain the water line above normal for steaming. Improved circulation to the heater will result.

(11) Brush exterior exposed iron work with a wire brush, and, after removing all rust, paint with rust proof heat resisting paint.

b. Steel boilers (dry method)

(1) Do all lay-up work for steel boilers immediately after the close of the heating season.

(2) Draw the fires, remove all combustibles, and drain the boiler while still warm. This prevents drying of loose mud, rust, and some types of scale.

(3) Open valves to all radiators and all other heating elements wide to permit condensate to drain back to the boiler, boiler feed pump, or opened piping drain points.

(4) Remove all manhole plates and washout plugs from the boiler and set to one side.

(5) Wash the water side boiler surfaces clean and remove all loose scale and sediment by flushing thoroughly with water pressure from a hose.

(6) Use all washout openings, starting at the lowest point in the boiler and working toward the top. Then repeat the washing by flushing from top down to lower openings.

(7) Open the city water or makeup water valve to flush the bottom of the boiler. When the boiler has been flushed, make certain this valve is closed tightly and does not leak.

(8) Flush out all boiler accessories such as water column piping, water column, gauge glass, pressure damper regulator, and steam gauge thoroughly. All automatic controls on mechanically fired boilers should also be cleaned thoroughly.

(9) It is important to clean the fire surfaces of the boiler. Fire tubes or flues should be punched or scraped thoroughly using a scraper which cuts down to the tube wall. Combustion surfaces should be brushed thoroughly with a wire brush to remove all soot, carbon, and scale. For coal fired boilers, remove the entire grate assembly from the boiler and set aside for inspection and repair.

(10) Scrape carbon and other foreign matter from the corners of the firebox as well as the inside of the firebox sheets, crown sheets, and front and rear tube sheets, using a wire brush and scraper.

(11) Clean soot and carbon from the outside firebox sheets, outer shell and throat sheet on all bricked-in-boilers. Clean inner brick walls and boiler shell including combustion chamber, smoke breeching and base of stack, of all soot.

(12) Remove all soot from the boiler room.

(13) Inspect the boiler thoroughly for any weakened or corroded places and have repairs made as early as possible.

(14) Coat all fire surfaces as far as possible with a mineral oil, giving special attention to fire tubes, corners of the firebox, and blow-off connection.

(15) Allow steel boilers to remain dry and empty all summer, permitting free circulation of air through all parts of boiler by keeping all doors and wash-out openings open.

(16) If the boiler room is damp or air circulation is poor, moisture may be absorbed by placing pans of unslaked lime in the boiler. Replace lime when necessary.

(17) For coal fired boilers, clean the grate assembly and inspect thoroughly. Replace any parts that are burned or even slightly warped.

(18) Make every effort to clean the boiler properly. A thorough cleaning is good assurance of freedom from boiler trouble throughout the next heating season.

c. Steel boilers (wet method). If a boiler is on standby service, the following wet method of boiler lay-up is recommended:

(1) Drain the boiler completely. Check to be certain that water walls and gauge columns are not overlooked. Next, open the boiler and wash clean and free from all loose scale and sediment by flushing thoroughly with strong water pressure. Use a stiff brush to clean all internal surfaces of the boiler that can be reached. Break the feed-water and steam connections to the boiler and blank the connections if other boilers are operating.

(2) Fill the boiler with either feedwater, return condensate or raw water, whichever is available. While the boiler is being filled, add the following:

(a) Caustic soda. (Caustic is added in sufficient quantity to maintain a PH of 9.5 to 11.)

(b) Sodium sulfite. (Approximately 0.03-0.06 pounds per 1,000 gallons of boiler holding capacity or 30-60 PPM.)

(3) Start a light fire in the furnace. Open the vent or safety valve and boil the water within the boiler under atmospheric pressure for two hours to ensure circulation of chemicals. When the water has cooled, fill the boiler to the top, overflowing safety valves to make sure complete filling is accomplished.

(4) Make periodic inspections to ensure maintenance of water level. Replace all water loss from the boiler. It may be necessary to add additional chemicals to the boiler to maintain the original concentrations of caustic soda and sodium sulfite.

4-91. Stokers.

At the end of the heating season, remove all coal, clinkers, and ash from stoker retort and grate area. Wire brush the hopper thoroughly and give it a coat of rust resisting paint. Drain the gear case of hydraulic drive oil, flush with clean flushing oil, and refill with oil of the viscosity recommended by the manufacturer. Clean the motor, electrical controls, refill oil and grease cups, open line switch, and close and seal switch box. Clean the retort carefully, remove ash and foreign material from air openings, and replace defective or burned out tuyere blocks as necessary. Patch or replace refractory of stoker heart and bridge wall if present. Run oil soaked sawdust or shavings through the screw to remove foreign material and leave screw and retort filled with clean, oiled shavings to prevent rusting during the lay-up period.

4-92. Oil burners.

Complete clean-up and check of oil burning equipment at the end of each heating season is necessary to assure proper operation during the following heating season.

a. Drain and clean strainer.

b. Oil all bearings with a good grade of medium motor oil at the end of the heating season and periodically during the heating season.

c. Clean the blower wheel, blower wheel housing, and air passages.

d. Inspect and clean automatic ignition devices.

e. Clean and inspect the combustion chamber for cracks and leaks.

f. Inspect and clean the nozzle. Sharp metal tools must not be used for cleaning nozzles. Inspect and clean the cup of rotary cup burners and the pot of pot type burners.

g. Clean sleeves, oil grooves, and the oil inlet pipe of range burners and replace the kindling wick if necessary.

h. Check automatic control and safety equipment for operation, contact points, and setting.

i. Inspect and clean the fuel oil tank if necessary. A full oil tank eliminates air and thereby prevents tank corrosion resulting from moisture condensation. Screen vents to prevent entrance of dust and dirt. Check the oil line for leaks.

4-93. Gas burners.

At the close of the heating season, procedures for lay-up of gas burners are relatively minor in scope. These consist briefly of cleaning the combustion chamber (including repair of refractory) and covering burner to prevent rust and entrance of foreign material. Check gas piping and valves in the boiler room carefully for leaks and check the control system and ignition system for proper operation.

4-94. Pumps.

Service switches to all pumps should be locked in the open position before starting repairs. At the close of the heating season, open the receiver and pump housing drains, remove all rust, sediment and other accumulations, flush thoroughly with clear water, remove inlet strainers, and clean screens. Open pump housing, wipe interior out, check moving parts for wear, make any necessary replacements, and remove the float from the receiver and check it for leaks. Motor driven vacuum pumps are equipped with various types of auxiliary valves with hardened metal, bronze, or composition surfaces, and are installed so that they are readily accessible. Check the manufacturer's drawing or service manual to ascertain proper methods of access to these valves. Inspect valves carefully and repair or replace seats and discs as necessary. It is of extreme importance that the valves of motor driven vacuum pumps be in proper operating condition to assure correct cycling of the unit. Clean the motor and electrical controls, open the line switch, remove fuses and place in the fuse box, and close and seal fuse and switch box. Leave the drain valve at the inlet to the pump open, and close pump inlet valve to prevent any trapped system water from returning to the pump during the lay-up period. Leave drain openings and plugs on the pump open, clean cap or plug threads carefully, and coat with oil to prevent rust. Coat the pump shaft with oil or grease to prevent rust. Clean the pump exterior and base thoroughly and give it a coat of rust resisting paint. Be sure to place new gaskets which may be required to reassemble the pump for service at the start of the heating system in a waterproof wrapper tied to the pump. Mark the wrapper, so that its contents can be identified easily. Be certain all guards on equipment are in place before starting the unit.

4-95. Valves and strainers.

Inspect and service the main shutoff and distribution system valves completely. Open the bonnets for repair of discs and seats, replace the packing and place a coat of light oil on the valve stem. Do not paint the valve stem or bonnet threads and bolts. Open check valves and clean and repair discs and seats as required. Open and clean strainers ahead of traps, control valves, and other similar pieces of equipment.

4-96. Traps.

a. Float-type traps. Open and clean out float-type traps at the ends of mains and at intermediate drip points carefully. Clean the valve head and seat with a soft clean cloth. Do not use files, chisels, or course abrasives to clean valves and seats. Check the condition of thermostatic diaphragms of traps which are equipped to vent air. Most traps have bottom drain plugs. Leave these plugs open during lay-up season, clean the threads carefully and coat with oil to permit easy assembly at the start of the heating season.

b. Thermostatic traps. Open and clean out thermostatic traps on radiators and other equipment with soft clean cloths. In replacing the threaded covers, clean threads and coat surface with a light even coat of oil or dried film lubricant conforming to military specification MIL-L-46147. The use of graphite on threads is not recommended as this material becomes corrosive when wet. Use new cover gaskets. Check diaphragms for correct operation before closing the trap.

4-97. Controls and electrical connections.

Check the wiring and conduit in the boiler control boxes which often are loosened during operating periods through carelessness with firing tools. Clean the interiors of control units of dust and soot accumulations, inspect and clean contact points, and close the boxes tightly. Equipment should be returned periodically to the manufacturers for factory overhaul and service as local conditions warrant.

4-98. Stack and breeching.

a. General. The stack and breeching will contain soot and other accumulations not readily removed during the operating period. Combustion products usually contain sulfur, which condenses and adheres to relatively cold surfaces of the stack and breeching. Sulfur combines with moisture in the air to form sulfuric acid which is very corrosive to metal breechings and stacks. It is therefore necessary to clean interior surfaces of steel breechings and stacks with a wire brush to remove soot deposits, and when surfaces are accessible, to apply a coating of heat and rust resistant paint. Proper respiratory and eye protection equipment must be worn by personnel engaged in cleaning stacks and breechings. Take the breeching down to permit access to the interior for proper cleaning procedures. Allow check dampers and access doors of breechings to remain open during lay-up periods to permit free air circulation.

b. Cleaning. The procedure to be followed for cleaning the stack depends on its size and accessibility. Relatively short stacks may be cleaned by use of a long boom with a pulley and a line at the top to permit inserting and moving a weighted brush or gunny sack filled with rags or excelsior up and down the stack. Accumulated soot may be burned out by kindling a paper and wood fire in the stack base. However, adequate provision for patrolling adjoining roofs and prevention of fire damage to buildings must be provided during the operation.

c. Lay-up. Provide steel stacks with a loose cap to prevent rain water from entering at the top during the lay-up period. Allow the bottom clean-out door and the breeching access doors to remain open during the lay-up period to permit air circulation. It will be found that with ample air circulation, soot and adhering scales will have a tendency to break loose. Soot and scale should be removed periodically to avoid corrosive action at the stack base or in the breeching. Brush exterior surfaces of steel stacks clear of rust and apply a coating of rust resisting paint when necessary. Clean and paint rust spots carefully since rust-through and permanent damage will occur quickly after the surface is exposed and the initial rust is visible, unless given immediate attention. Rust and corrosion of steel stacks and breechings occur from both the inside surface and from the outside surface. Rust and corrosion prevention on inside surfaces may be difficult because of limited accessibility. However, exterior surfaces can be readily protected and the stack life prolonged by prevention of rust and corrosion from the outside.

Section XIX. ENERGY CONSERVATION

4-99. Isolate off-line boilers.

Light heating loads on a multiple boiler installation are often met by one boiler on-line with the remaining boilers idling on standby. Idling boilers consume energy to meet standby losses, which can be further aggravated by a continuous induced flow of air through the boiler into the stack and up the chimney. Unless a boiler is scheduled for imminent use to meet an expected increase in load, it should be secured and isolated from the heating system (by closing valves) and from the stack and chimney (by closing dampers). A large boiler can be fitted with a bypass valve and regulating orifice (figure 4-32) to keep it warm, thereby avoiding thermal stress when it is brought on-line again. If a boiler waterside is isolated, it is important that air flow through the stack is prevented; it is possible for back flow of cold air to freeze the boiler.

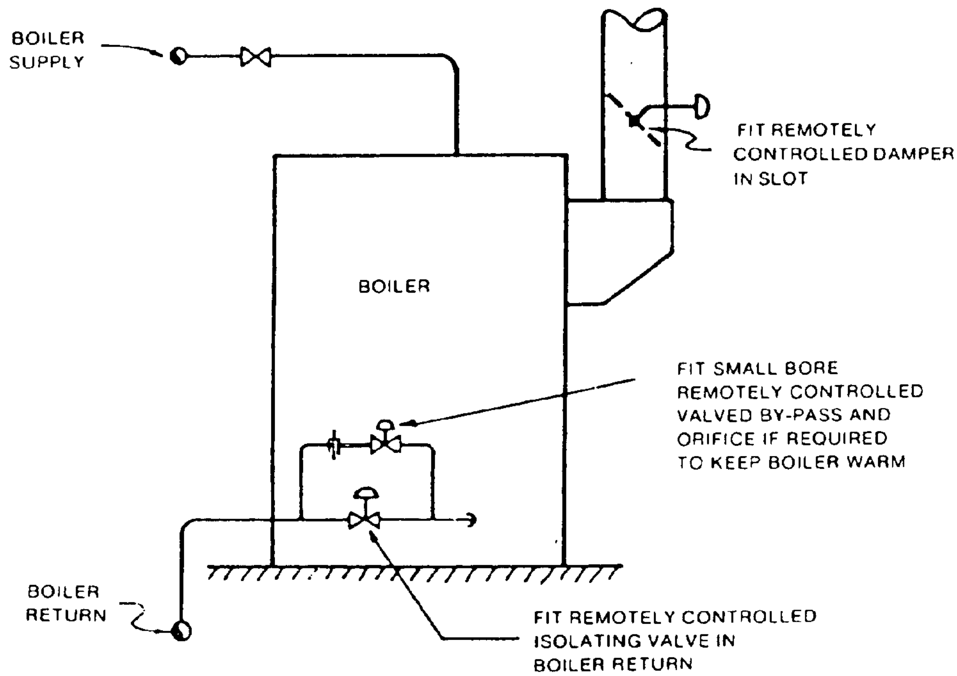


Figure 4-32. Warm-up bypasses for a secured boiler.

4-100. Maintenance of pipe and boiler insulation.

Existing pipe insulation that is in a bad state of repair, should be stripped off and replaced. If the worn sections are restricted to a few locations, the insulation should be replaced in those areas only. If there is any doubt about whether or not the insulation is asbestos, a sample should be taken and analyzed. If it proves to contain asbestos the removal should be handled in accordance with established policy. Where hot pipes are insulated but the insulation is of minimal thickness and effectiveness, additional insulation should be applied over the existing insulation. Do not insulate steam traps or the first six feet of the condensate discharge piping from the trap, except where personnel could come in contact with hot surfaces. Check with the local fire authorities to determine whether the selected insulation is acceptable or is considered a fire or smoke hazard. In buildings where food is either stored, processed, or sold, avoid the use of fibrous insulating materials if there is any possibility of fiber migration. Consult the Food and Drug Administration for prohibited materials.

4-101. Steam trap leak detection.

Failure to detect signs of early steam trap wear and dirt build-up, because of the lack of a regular trap inspection program can result in large energy losses and heat exchange equipment failure. No single inspection technique can be used to check all traps, but a combination of the following general procedures should be incorporated into any steam trap inspection program.

a. Visual testing A test which allows visual inspection of a steam trap's operation is considered to be the best approach. The method must be used with the knowledge that it is not infallible and that its reliability varies among the various types of traps. This procedure requires an isolation valve in the condensate line downstream of the trap and a test valve in a tee stubbing off the condensate return line just between the trap and the downstream isolation valve. The purpose of this "block and Bleed" valve arrangement is to isolate the trap discharge from the condensate return system and allow its inspection through the test valve. A typical arrangement is illustrated in figure 4-33. The inspection of trap operation requires that the isolation valve in the condensate return line be closed and the test valve be opened. Observation of the discharge from the test valve offers excellent insight into the operation of the trap. The possibilities are discussed below:

(1) Nothing is discharged from the test valve.

(a) Trap may have failed in the closed position.

(b) There may be a vacuum in the system heat exchange unit preventing draining.

(c) There may be a leaking bypass valve upstream of the trap.

(d) Debris may be clogging the trap or line and only cleaning of the strainer and trap may be required.

(e) System pressure may be too high for the trap due to trap wear, incorrect sizing, malfunctioning pressure reducing station, or vacuum in the return line.

(f) The air vent may not be functioning correctly.

(g) The trap may be installed backwards (if it is a thermodynamic disc trap).

(2) A continuous discharge is emitted from the test valve.

(a) This may indicate that no problem exists. For example, float and thermostatic (F&T) traps and orifice plates may continuously discharge condensate which can flash into steam when released to the atmosphere. It is very important to have a trained and skilled observer who can distinguish between superheated steam leaking through a failed trap and flash steam (saturated steam formed when condensate is released to the atmosphere).

(b) This may indicate, on some trap types, that the trap has failed in the open position.

(c) The trap may be too small for the application.

(3) The discharge from the test valve is intermittent, with no appreciable water or steam visible between discharges.

(a) Trap may be functioning properly.

(b) May be an indication of failure in orifice plates or F&T traps which are designed for continuous discharge.

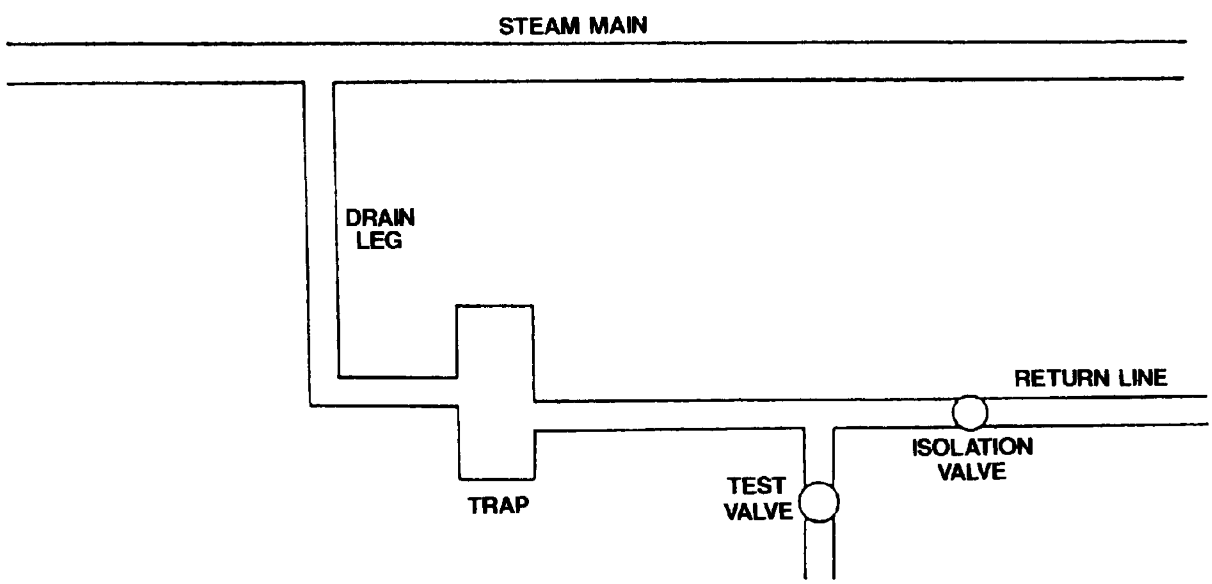


Figure 4-33. Steam trap test valve set-up.

b. Audible testing. Holding one end of a steel rod or stethoscope firmly against the trap cap and listening at the other end is a popular method of testing traps. The use of this technique requires considerable experience in order to differentiate between indicative trap noises and other noises that may be transmitted through adjacent piping. The following descriptions of various trap sounds have been given credence by trap manufacturers and practitioners of the conventional audible inspection:

(1) *Bucket traps.* A properly operating bucket trap will make a cycling sound as it opens and closes. A failed bucket trap (they always seem to fail open) has been described as making a whistling sound or a “whooshing” sound.

(2) *Thermostatic traps.* A properly operating thermostatic trap will make no sound, the sound of periodic discharge may be heard, or continuous but fluctuating sounds may be heard. A thermostatic trap failed closed will make no sound; a thermostatic trap failed open will make a whistling sound.

(3) *Thermodynamic traps.* A properly operating thermodynamic trap will make a clicking or snapping sound as it opens and closes several times

per minute. A failed trap will make a rapid chattering sound.

c. Ultrasonic testing. A more modern, yet more costly, approach to steam trap testing involves the application of ultrasound. An ultrasonic leak detector is a listening device that detects sound in the high frequency range. With this equipment, the operator can hear the movement of steam within the trap without interference from other sounds. Again, experience with both the equipment and the methods is required for satisfactory results. The following noise descriptions are given as a general guide.

(1) *Bucket traps.* Operation is intermittent. The tester will easily learn to distinguish between normal and malfunctioning operation. When the trap is working properly a hissing noise will be heard during discharge; when the trap closes, the noise should stop. Continuous "hissing" indicates that the trap has failed open (blowing), which may result from a loss of prime under light loads or a malfunction of the trap mechanism.

(2) *Thermostatic traps.* When properly sized, will discharge intermittently; therefore, if the trap is operating properly, a loud hissing sound will be heard during discharge; no sound will be heard when the trap is closed. If hissing continues after closing, the trap is leaking. If the condensate load exceeds the leakage, only condensate will be lost from the trap. If the condensate load is less than the leakage, however, the hissing will continue for a prolonged period and steam will be lost. The trap will cycle only when the condensate load again exceeds the leakage, and subcooling of the condensate occurs in the trap. If the trap continues to cycle regularly, it is probably functioning properly. Some thermostatic traps tend to throttle under certain load conditions. When these conditions exist, the test instrument will emit a continuous hissing. When this occurs, the trap can be tested only by reducing the load. Under low load conditions, even these traps cycle rhythmically.

(3) *Thermodynamic traps.* The trap opening and closing frequency depends upon the trap load and the mechanical condition of the trap. If the trap cycles fewer than ten (10) times per minute, it is operating normally. If the trap is worn, its cycling rate will increase significantly; if the trap discharges continuously (no cycling), the loading may exceed the capacity or the return line pressure (downstream of the trap) may be too high. Line pressures both upstream and downstream of the trap should be checked.

(4) *Impulse traps.* These traps are intermittent in operation. With the trap closed, a hissing sound will be heard, but the trap is not necessarily wasting steam. If properly sized, it should still continue to operate intermittently while hissing. A loud roar when the trap is in the discharge position followed by a much lower noise level indicates proper operation. If, however, a loud noise is heard continuously, the trap is either overloaded or failed in the open position.

(5) *Float and thermostatic traps.* These traps have a tendency to discharge continuously (particularly at low to moderate pressures) and modulate with the loads upstream of the trap. Under these conditions, ultrasonic testing is of no value. However, when F&T traps are used at high pressure, they tend to discharge intermittently, and, if the equipment indicates a rhythmic intermittent discharge, the trap is working properly.

d. Temperature testing Measuring the temperature of the condensate pipe beyond the trap was once touted as a reliable means for checking steam trap operation. Another temperature check regimen was to measure the temperature difference between the pipes entering and leaving the trap. Today, condensate pipe temperature is deemed a reliable indicator of trap operation only if the trap has failed closed. In this case, the trap and adjacent downstream pipe will be very close to ambient temperature. Claims have been made to the effect that a pipe surface temperature measurement in conjunction with a steam pressure measurement at the trap will allow accurate diagnosis of steam trap condition and operation; however, obtaining a trap pressure measurement requires considerable effort and expense, thus defeating the purpose of a simple, inexpensive test method. There remain, however, some technicians who advocate the use of a temperature test method for judging the condition of a trap. For those determined to use this test method, the temperature measurements should be made with a pyrometer, an infrared photometer, or by a crayon type temperature indicator. The following observations and assumptions can be made through the use of the temperature testing method:

(1) If the condensate line is at ambient temperatures, the trap has failed in the closed position.

(2) If the condensate line is warm or hot:

(a) The trap is functioning properly.

(b) The line temperature is influenced by other traps discharging into the same condensate return line and the trap under observation is actually malfunctioning.

(c) The trap has failed in the open position.